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(54) Detector apparatus

(57) Detector apparatus comprises a plurality of oscillators each comprising a tuned circuit 35, 36 coupled through respective terminals 31 and 32 to inductive loops.

The feedback loop 41 of each oscillator is enabled in turn by applying a signal to a respective control line 42 which includes a diode 44 and capacitor 45 in parallel to speed turn on. The oscillator outputs are fed through circuits (52 and 53) which gate a clock (54) during the fifth to twelfth oscillation of each enabled oscillator. The gated clock count gives a measure of the frequency of the oscillator which depends on the inductance of the loop which is varied by the presence of a vehicle. Arrangements are made to recalibrate each loop to allow for extraneous variations in inductance and for vehicles parked on a loop. Time information and vehicle presence information is fed to a microprocessor (22) to provide vehicle statistics.

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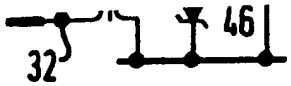

FIG.2.

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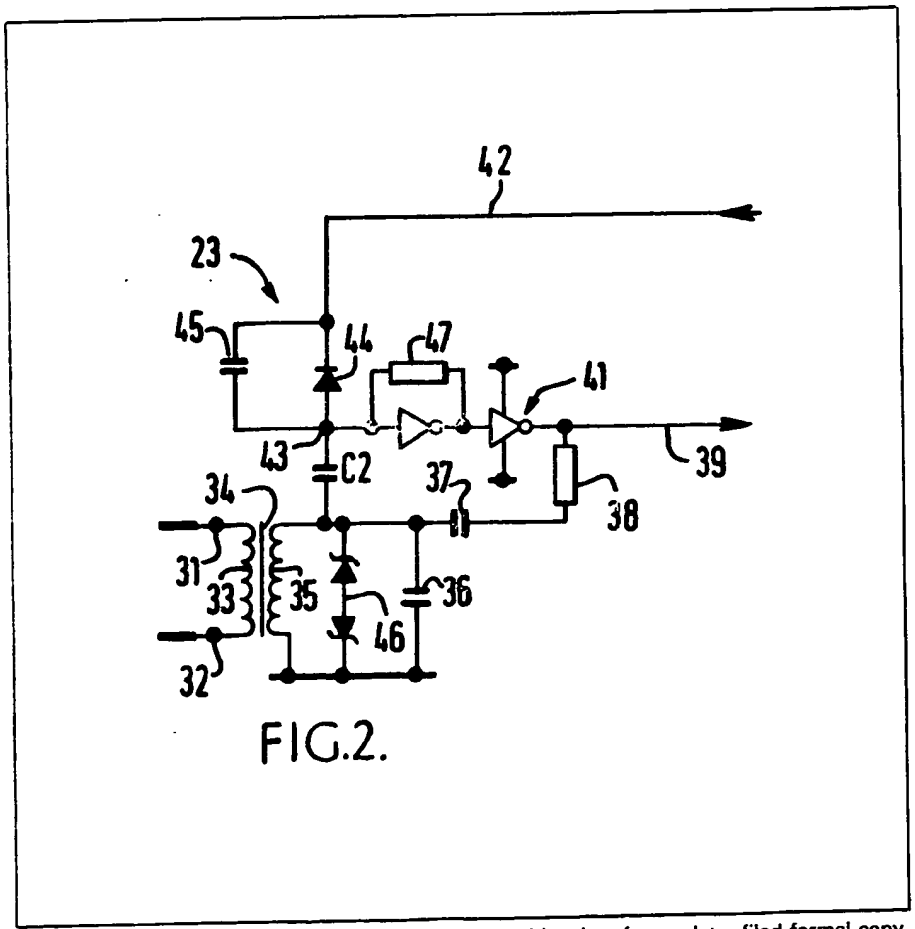

FIG.2.

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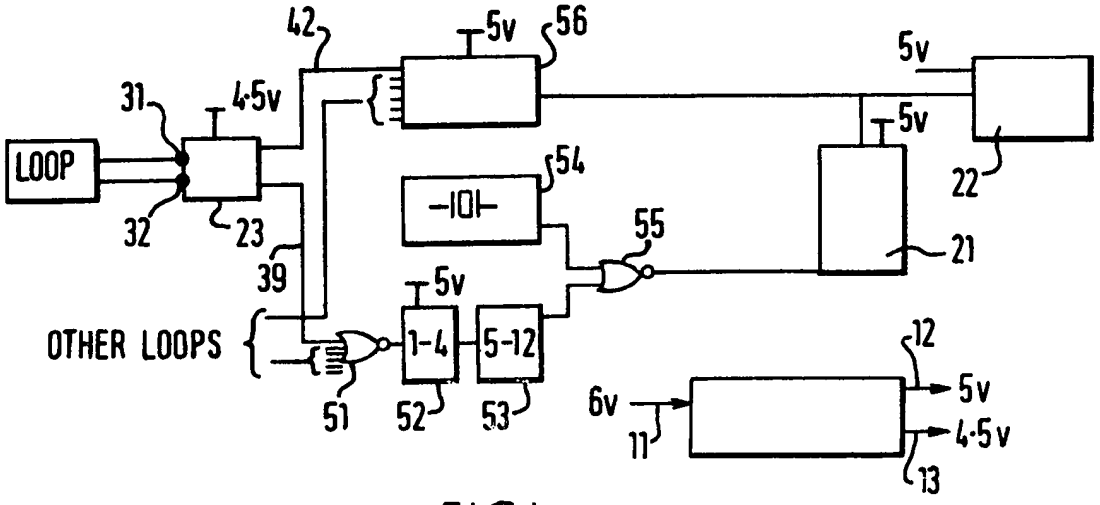

FIG.1.

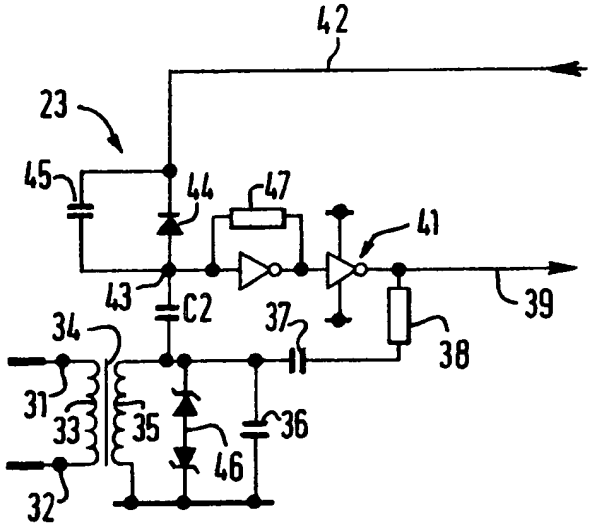

FIG.2.

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SPECIFICATION

Detector apparatus

This invention relates to detecting apparatus for detecting metal objects. It can be used for detecting a vehicle in an area on the carriageway. Such apparatus includes a loop laid in the roadway, usually with rectangular configuration, parallel to the surface, the loop being connected by means of a transformer to an oscillating circuit. The presense of a vehicle above the loop reduces its inductance, thereby increasing the natural frequency of the oscillator. Such apparatus can be used for example to control traffic signals or to provide traffic statistics in terms of the density of traffic, and the velocity and length of individual vehicles.

It has been proposed to measure the frequency of the oscillator by counting the number of oscillations in a given period. This count has been processed in conjunction with a time clock in digital apparatus to provide the required information. We have found it better to measure the time for a predetermined number of oscillations.

It has also been proposed to operate a plurality of loops in conjunction with the time clock and processing apparatus, using a single oscillator which is switched in turn to each loop, or using individual oscillators for each loop. When the single oscillator is switched to a new loop, or when an oscillator connected to a loop is switched on, the initial oscillations are unstable and/or of small amplitude, and cannot be relied upon to operate the digital apparatus accurately. We have found that in detecting apparatus in which an oscillator is switched on by the appplication of a signal through a control line containing a diode, the operation of the oscillator is considerably improved if a capacitor is connected parallel with the diode so that the capacitor discharges on application of a signal on the control line in order to boost the oscillator into full oscillation as soon as possible after application of the signal.

We have found that individual oscillators connected to respective loops provide better performance, in contrast to a single oscillator which is switched between them, since it is possible to arrange for the oscillation in conjunction with one loop to be starting up at the same time as the oscillator in the previously used loop is being switched off. Increased speed of operation enables the apparatus to have higher resolution, or the timing and digital processing apparatus to be used in conjunction with a greater number of loops.

Although the individual steps of the digital processing operation are carried out in terms of microseconds, some of the operations require a large number of steps and the digital processing apparatus may still be processing information from one loop when further information is available from the next loop. We therefore prefer to provide in our detector apparatus a buffer which accepts the information from the individual loops, and feeds the stored information to the main processor when in it is ready to process that information.

This type of vehicle apparatus is arranged to detect the presence of a vehicle by comparing the signal representing the current frequency with a reference. A threshold can be set for the comparison. The reference can be adjusted to recalibrate the loop of the inductance of the loop changes other than due to the presence of a vehicle, or if a very large difference between the current frequency signal and the reference is detected continuously for a long period.

The various aspects of the invention set out in the preceding paragraph may be used independently of each other. For example, the recalibration of a loop can be used in detecting apparatus which does not have a capacitor in the oscillator enabling means.

An example of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic block diagram of a vehicle detecting apparatus, and

Figure 2 is a circuit diagram of an individual oscillator circuit used in the apparatus of Fig. 1.

The illustrated detecting apparatus has a six volt power supply which is applied on line 11 to a voltage regulator which provides a controlled five volt output on line 12, and a specially stabilised 4.5V output on line 13. The five volt output is supplied to various components of a buffer 21 and a main microprocessor 22, to be described later. The specially stabilised 4.5 volt output is applied to individual oscillators 23.

The detecting apparatus is intended for use with up to six loops. These loops are laid parallel to the surface of a vehicle track, and are usually rectangular and of the order or six feet across. The detecting apparatus has a pair of input terminals 31 and 32 for each loop, and as can be seen from Fig. 2 the terminals are connected across the primary winding 33 of a transformer 34. The secondary winding 35 of the transformer 34 forms a resonant circuit with a capacitor 36, the output of the resonant circuit being fed through a capacitor 37 and a resistor 38 to an output line 39. A pair of zener diodes 46 are connected across the resonant circuit to reduce noise and protect against disturbances such as lightning strikes. Positive feedback is provided by a loop generally indicated by 41, and a control line 42 is connected to a point 43 on the loop 41 through a diode 44 in parallel with a capacitor 45. The positive feedback loop 41 contains a resistor 47 in parallel with

an inverter circuit to ensure that the oscillation is symmetrical about the zero voltage line.

A low voltage signal applied on the control line 42 inhibits the operation of the feedback loop 41 so that the oscillator does not produce an output. In the absence of the capacitor 45, when the voltage on the control line 42 is allowed to rise, oscillations slowly appear on the output line. With digital processing apparatus, this slow increase in oscillation is undesirable, and the addition of the capacitor 45 causes a pulse of the right size and shape to be injected into the output line so as to cause the oscillator to generate oscillations of full amplitude as soon as the voltage on the control line 42 rises. We have found that the provision of the capacitor 35 enables the period during which each loop is scanned to be reduced from about twenty milliseconds to about one half millisecond, a factor of forty. Resolution of the detecting apparatus is thereby increased.

The signal representing the frequency of oscillation is processed to provide an indication of the presence or absence of a vehicle. The frequency of oscillation will depend on the inductance of the loop connected to the terminals 31 and 32. When a vehicle or other metal body is located above the loop, the inductance will be decreased, so that the frequency of oscillations of the output line 39 will be increased. The output line 39 of the individual oscillators are connected through an OR gate 51 to clock circuits 52 and 53. The first gate 52 rejects the first four oscillations. It has been found that although the provision of the capacitor 35 starts the circuit oscillating at or near full volume when the control voltage rises, the oscillations are still a little unstable and it is better to reject the first four oscillations. The second gate 53 accepts the next eight oscillations and gates the counts from a clock 54 by means of an OR gate 55 during the period of the next eight oscillations to provide a digital representation of the period occupied by those eight oscillations. When the frequency of the oscillator circuit is increased by the presence of a vehicle above the loop, the digital representation will be of a lower number than when no such vehicle is detected.

The digital representation is subtracted from a reference count. If the difference is small (within a count of 7), an absense of a vehicle is indicated. Otherwise the presence of a vehicle is indicated, and the difference count may be as high as 32,000.

The reference count can be adjusted to correct for errors. For example the inductance of a loop may vary due to changes in atmospheric conditions and not due to the presence of a vehicle. When the difference count is within a range of + 7 to − 7 inclusive, than the reference count is incremented by 1 towards the current count once every second. The reference count will follow any slow drift in loop inductance.

When the difference count is greater than 7, a 5 timer is incremented by one count at a frequency of 12.5 Hz. The timer is reset if the difference count drops below 8, but if the timer reaches a count of 2048 (as it will after a continuous vehicle presense count of 164 seconds) the reference is changed to the current digital representation. This has the effect of making the loop sensitive to changes from the conditions existing for the last 164 seconds, which changes (apart from the departure of the vehicle which caused the high difference count) would otherwise have been ignored. The apparatus can therefore continue to make useful detections even if a vehicle has stopped a part of a loop for over 164 seconds.

When the difference count is a negative figure numerically greater than 7 a similar timing count is started, but at a rate of 200 Hz, the timer being reset if any count is no longer a negative figure numerically greater than 7. When the timing count reaches 2047, as it will after 10.25 seconds of continuous such counts, the reference is reset at the current digital representation. The apparatus thus responds quickly to the departure of a vehicle which caused recalibration of the loop by a large change in in the reference count.

The buffer information is simply a series of times and indications whether the six loops are detecting the presence or absence of vehicles. The main microprocessor processes this information to provide a series of statistics relating to fifteen-minute intervals. For each interval, the main microprocessor produces the total number of vehicles in various speed bands, and can also be arranged to produce totals of the total number of vehicles in various length bands.

The main microprocessor 22 controls the operation of a loop selector circuit 56 which applies an increased voltage to the control line of the oscillator circuits in turn. A hardware switching device can be connected to the processor to select whether four or six loops are to be used in a scanning cycle.

CLAIMS:–

1. Detector apparatus including oscillator means adapted to be connected to an inductive loop for oscillating at frequencies dependent on inductance of the loop and means for enabling the oscillator means, said enabling means including a capacitor to assist the initial oscillation of the oscillator means when enabled.

2. Apparatus as claimed in claim 1 comprising means to convert the frequency of the oscillator means to digital information, processor means to process the digital information and a buffer connected between the converting means and the processing means.

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3. Apparatus as claimed in claim 1 or claim 2 wherein the oscillator means comprises a plurality of oscillators, each adapted to be connected to a separate inductive loop, the enabling means being arranged to enable the oscillators in turn.

4. Apparatus as claimed in any one of claims 1 to 3 comprising means to compare a signal representing the current frequency of the oscillator means with a reference and means to increment the reference towards the signal representing the current frequency when the arithmetical value of the difference therebetween is below a predetermined value.

5. Apparatus as claimed in claim 4 comprising timer means incremented in response to said difference being above said predetermined value and means to set the reference at the signal representing the current frequency when the timer reaches a predetermined count.

6. Apparatus as claimed in claim 4 or claim 5 comprising timer incremented in response to said difference being a negative value numerically greater than said predetermined value and means to set the reference at the signal representing the current frequency when the last-mentioned timer means reaches a predetermined count.

7. Apparatus as claimed in any one of the preceding claims comprising means to measure the period occupied by a predetermined number of oscillations from the oscillator means when enabled.

8. Apparatus as claimed in claim 7 wherein said measuring means is arranged to be responsive to the oscillations between a first predetermined non-zero number and a second predetermined number.

9. Detector apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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